

A PRELIMINARY GUIDE FOR AGE AND SEX DETERMINATION OF THE HOUBARA BUSTARD *CHLAMYDOTIS UNDULATA MACQUEENII*¹

NIGEL S. JARRETT AND STEPHANIE M. WARREN²

(With four text-figures and three plates)

Key words: Age determination, sex determination houbara bustard, *Chlamydotis undulata macqueenii*

For 16 first year and 20 adult captive houbara bustard *Chlamydotis undulata macqueenii*, data were collected on the moult sequence and feather characteristics of wing and tail plumage. First year birds replaced most juvenile plumage with first adult plumage before age 6 months, but retained various inner secondaries, greater secondary coverts, outer primaries and corresponding coverts, and outer tail feathers for at least 10-11 months. A free-living houbara, caught in Kazakhstan in May, had retained juvenile outer primaries, primary coverts, inner secondaries and outer tail feathers. These data suggest that the presence of retained juvenile plumage may enable field workers handling free-living houbara to separate birds in their first calendar year from adults. The feather characteristics (shape, colour and pattern) of relevant juvenile and adult plumage are presented, and criteria for separating the two age classes are highlighted.

Morphometrics (head, culmen, tarsus, middle toe and sternum length) were taken for 129 adult birds of known sex. For each morphometric variable, males were significantly larger than females (between 9% and 15%). However, the range of each variable overlapped between the sexes. Discriminant analysis of morphometric data correctly classified the gender of 99% of individuals: 100% of females and 98.7% of males; one male was misclassified. The same result was achieved whether all five variables, or two variables only (head and tarsus), were used in the analysis. Equations to classify the gender of adult birds are presented.

INTRODUCTION

Cramp and Simmons (1980) note that after fledging, juvenile houbara bustard undergo a complete moult in which all feathers except a variable number of outer primaries and outer tail feathers are replaced by mid-winter. However, specific feather characteristics have not been described in sufficient detail to enable field workers handling houbara to separate first year birds from adults.

Similarly, male and female houbara cannot always be separated easily: although male houbara are significantly larger than females (by approximately 10%), the ranges of morphometric variables overlap between the sexes. Also, despite the feathers of the crown

and neck ruff being described as shorter in females, the plumage of adult houbara does not show obvious sexual dimorphism, particularly during the non-breeding season (Cramp and Simmons 1980, Johnsgard 1991). Furthermore, while observation of the elaborate courtship display may indicate the gender of male houbara at certain times of the year, female houbara also perform this display sometimes. (Mendelssohn *et al.* 1979, Launay and Paillat 1990, Gaucher *et al.* 1996, Owen pers. comm.).

We present a preliminary guide for 'in-the-hand' age and sex determination of the *C. u. macqueenii* subspecies using data collected from birds in captivity. The moult sequence and the feather shape and pattern of wing and tail plumage of first year and adult birds are described, and recommended as criteria to ascertain age. For adult houbara, univariate morphometric data, and the results of discriminant analysis to classify gender, are

¹Accepted November, 1997

²Department of Agriculture and Environmental Science, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU

presented. In future, it should be possible to establish the age of *C. u. macqueenii* (as either first year or adult birds) using plumage characteristics, and to establish the gender of those birds classified as adults (with a known degree of precision) using equations incorporating morphometric data.

METHODS

The study was conducted at the National Avian Research Center (NARC), now part of the Environmental Research and Wildlife Development Agency (ERWDA) of Abu Dhabi, United Arab Emirates (UAE). NARC is an ecological research organisation concerned primarily with the conservation of the houbara bustard and its habitat. NARC currently holds 190 captive houbara of the subspecies *C. u. macqueenii*. This race occurs from the Arabian Peninsula and north Caspian Sea, east to Mongolia (Cramp and Simmons 1980). Most of the houbara in NARC's care were translocated from Pakistan to Abu Dhabi, adult birds caught in the wild during the early 1980's, and were transferred to NARC in 1993.

State of moult was assessed and recorded for 10 male and 10 female adult houbara handled in April and September 1993, January and November 1994 and November 1995. The gender of these birds was ascertained surgically, using an endoscope. More generally, moult status was recorded for all birds by noting the presence or absence of moulted feathers in bird enclosures on a monthly basis. In November 1995, a photographic record was made of wing and tail feather plumage for five birds of each sex. Feather samples were collected at this time: feathers were removed by cutting the rachis with scissors, approximately 1cm above the feather follicle. Samples included: secondary 7, greater secondary covert 7, primary covert 6, primary covert 8, and outermost and second from outermost tail feathers.

For 16 houbara aged less than one year (hatched in 1995) the sequence of post-juvenile

moult was recorded from July 1995 until April 1996. In November 1995, a photographic record was made of wing and tail feather plumage and feather samples were collected. Samples included: secondary 7, greater secondary covert 7, primary coverts 6, primary coverts 8, and outermost and second from outermost tail feathers.

In addition, the first author examined five free-living houbara caught in the Taukum Desert of Kazakhstan in May 1996. A photographic record was made of wing and tail feather plumage.

For 129 adult houbara (birds older than one year) of known gender (ascertained by endoscopy), the following measurements were taken by the first author using dial callipers: head length (see Fig. 1); culmen length (the chord from tip of upper mandible to root of feathering); tarsus length (see Fig. 2); middle toe length (the dorsal measurement from the joint with the metatarsus to the tip of the claw); and sternum length (the length of the keel from the xiphisternum to the cranial edge).

Discriminant analysis of the morphometric data to generate a discriminant function and equations to classify the gender of unsexed birds was performed using the SYSTAT statistical package (SYSTAT 1992). The discriminant function was a linear combination of the

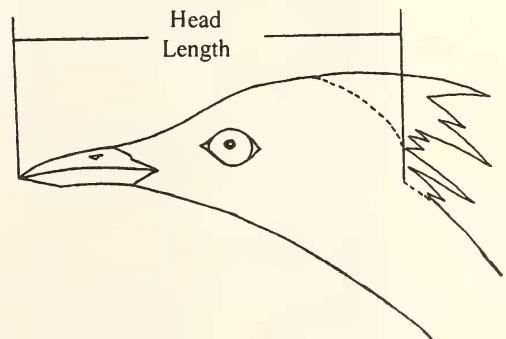


Fig. 1: Head length measured from the external occipital ridge (at back of the head - including skin) to the distal tip of the bill nail.

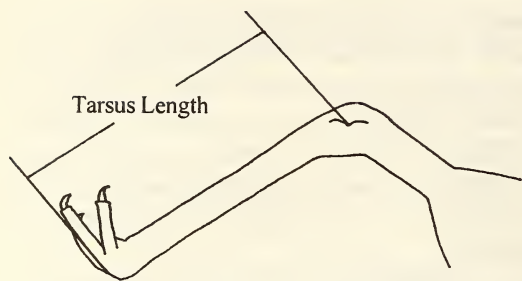


Fig. 2: Tarsus length measured diagonally on the outside edge of the left leg from the notch at rear of tarsometatarsus to the prominent edge formed when the toes are bent back approximately 90° to the tarsus.

morphometric variables, weighted so that the statistical difference between the sexes was maximised. The analysis was performed twice: once with all five morphometric variables, and once with two morphometric variables only (head and tarsus length).

Note that in the Results and Plates sections, 'juvenile' refers to post-downy plumage and 'adult' refers to the feather generation replacing juvenile, and all subsequent adult-like plumages. 'First adult' is used only in Plate 2, Fig. 4 to indicate the first post-juvenile generation of outer tail feathers.

RESULTS

Age determination

Moult strategy - adult. Adult houbara underwent two moult cycles. Post-breeding (beginning late May/early June and continuing to late September), various body and tail feathers, followed by the elongated feathers of the crown, sides of neck and chest, were replaced. Primary moult began and progressed descendantly to primaries 5-8. Pre-breeding (beginning in November and continuing to March), the feathers of the sides of the crown, foreneck, hindneck and mantle were moulted and replaced by elongated plumes. Some belly, wing covert feathers and the outer primaries were renewed at this time.

Moult strategy - juvenile. Shortly after fledging, at the age of 2-3 months (July-August), moult began. Tail feathers were replaced centrifugally, beginning with the central pair, and a variable number were replaced before moult was suspended in September. Two to three secondary feathers were moulted ascendantly and lesser, median, and greater upperwing coverts were replaced in a random pattern. Primaries were moulted ascendantly and by age 3-4 months (August-September), primary feathers 3-6 had been moulted in all birds. Primary coverts were replaced either at the same time, or just after the primary feathers were shed. Moult was suspended for a variable period in autumn, but was usually resumed at age 6 months (late October to November), and proceeded with replacement of the feathers of the crown, sides of neck and chest (tracts of elongated feathering), and remaining juvenile tail, secondary and lesser, median and greater secondary covert feathers. In January, when birds were aged approximately 6 months, nearly all juvenile plumage had been replaced by an adult-like feathercoat. By April, nearly all birds had still not moulted a variable number of juvenile feathers including inner secondaries, greater secondary coverts, outer primaries and corresponding coverts and the feathers of the alula. Only one bird did not show any retained juvenile plumage in at least one of these feather groups. These data from captive first year birds indicate that retained juvenile feathering can be used to separate yearlings from adults up to April, when they are aged 10-11 months.

Of the five wild houbara caught and examined at a single display site in Kazakhstan in May 1996, one bird showed retained juvenile primaries 6-10 and primary coverts 6-10, some inner secondaries and the outer tail feathers. This bird was believed to be a yearling. In contrast, the other four birds showed complete adult-like plumage and were considered to be full-grown adults. This suggests that free-living yearlings are separable from adult birds at an age of approximately 12 months.



Fig. 1

Fig. 1: Primary Covert 6. Juvenile (top), Adult (bottom). Pairs of feathers: female left, male right. Gender is tentative for juvenile.
 Fig. 2: Secondary 7. Juvenile (top), Adult (bottom). Pairs of feathers: female left, male right. Gender is tentative for juvenile.



Fig. 2



Fig.3

Fig. 3: Greater Secondary Covert 7. Juvenile (top), Adult (bottom). Pairs of feathers: female left, male right. Gender is tentative for juvenile.
 Fig. 4: Outermost Tail 1 & 2 (male). Juvenile (left), first adult (centre), adult (right). Gender is tentative for juvenile and first adult.



Fig. 4



Fig. 5



Fig. 6

Fig. 5: Wing of free-living Houdara caught in May in Kazakhstan, first year male bird (aged approximately 12 months). Retained juvenile primaries 6-9, primary coverts 7-9 visible.

Fig. 6: Wing of free-living Houdara caught in May in Kazakhstan and identified as an adult male bird. Note that inner primaries and their coverts are new.

The following differences in feather characteristics were apparent between retained juvenile and adult plumage.

OUTER PRIMARIES (not illustrated)

Juvenile - Short and narrow, with pointed tips when new. Bases to primaries 7-10 white, and distally, brownish-black with pale buff or cream-white tips and subterminal bars.

Adult - Long and broad. Bases white and tips black.

PRIMARY COVERTS (Plate 1, Fig. 1: Primary Covert 6)

Juvenile - Short, narrow and tapering. Muted dark-brown, palest on inner vane. Outer vane pale buff at the feather base, lightly flecked dark-brown. Inner vane fading from dark-brown to buff towards feather base. Cream to pale buff feather tip showing variable amounts of brown flecking.

Adult - Long and broad with rounded tip. Sooty-black, with buff-white to pale cinnamon bases. Vermiculated brown black and sometimes heavily, on pale areas of outer vane adjacent to solid dark areas.

SECONDARIES (Plate 1, Fig. 2: Secondary 7)

Juvenile - Short, narrow and tapering to a rounded tip. Dirty-brown with white tips, variable amounts of subterminal buff vermiculation with bases off-white on inner vane, pale buff on outer vane. On inner vane, small amount of brown vermiculation on pale area where this meets the dark area of the feather.

Adult - Long and broad, less tapered to rounded tip. Sooty-black with bases having brownish-white or cream inner vanes and pale buff outer vanes. New feathers sometimes show narrow white tip to feathers. On inner vane, variable amount of brown black vermiculation on pale area where this meets the dark area of the feather.

GREATER SECONDARY COVERTS

(Plate 2, Fig. 3: Greater Secondary Covert 7)

Juvenile - Narrow and tapering to a pointed and usually worn tip. Feathers translucent, pale buff or cream with variable patterning, ranging from narrow black vermiculation, to pale brown barring.

Adult - Broad with rounded tip. Pale cream to buff-white, finely vermiculated black. Black subterminal bar and white tips.

OUTER TAIL (Plate 2, Fig. 4: Outer Tail 1&2)

Juvenile - Narrow and tapering, usually to a worn tip, appearing more pointed than adult feathers. Faded cinnamon brown in colour with brown to black subterminal bar and whitish tip. Three to five (usually three) dark brown and often incomplete transverse bars. Cinnamon brown base colour is lightly vermiculated.

Adult - Broad. Buff coloured with a broad cream-white tip. Three dark brown (almost black) broad transverse bars with silver iridescence. The buff base colour is heavily vermiculated with black, between and near to the transverse bars. Sometimes, birds show vermiculation between white tip and first transverse bar, others have white of tip extending to outer transverse bar.

Plate 3, Fig. 5 shows the wing of the free-living houbara caught in Kazakhstan which was identified as a first year bird (aged approximately 12 months old). Note the combination of juvenile and (first-) adult primary coverts. Plate 3, Fig. 6 shows the wing of a free-living houbara caught in Kazakhstan and which was identified as an adult male bird.

Sex determination of adults

Of the 129 adult houbara for which gender had been determined using an endoscope, 79 individuals were identified as males and 50 were identified as females. There were significant

AGE AND SEX DETERMINATION OF THE HOUBARA BUSTARD

TABLE I
MEASUREMENTS (MM) OF ADULT MALE AND FEMALE HOUBARA. MALE TO FEMALE (M:F) RATIO AND RESULTS FROM UNIVARIATE *t* TESTS ARE ALSO SHOWN

Variable	Males				Females				M:F	<i>t</i>	<i>df</i>	<i>P</i>
	<i>n</i>	Mean	Range	<i>SD</i>	<i>n</i>	Mean	Range	<i>SD</i>				
Head	79	103.65	97.2-110.4	2.75	50	95.01	89.2-100.1	2.35	1.09	19.03	116	<0.0001
Culmen	79	41.82	33.3-49.5	2.93	50	38.12	32.4-44.1	2.58	1.10	7.53	113	<0.0001
Tarsus	79	99.91	88.7-106.8	3.73	50	88.26	80.0-95.7	3.80	1.13	17.09	103	<0.0001
Sternum	78	104.61	83.4-114.6	5.61	49	91.04	80.1-99.8	4.62	1.15	14.80	115	<0.0001
Middle toe	78	47.58	35.0-57.4	4.27	49	41.51	33.8-48.4	3.57	1.15	8.63	115	<0.0001

differences between the sexes for each morphometric variable (Table 1, Fig. 3); males being, on an average, between 9% (head measurement) and 15% (sternum measurement) larger than females.

Discriminant analysis using all five morphometric variables correctly classified 99.2% of individuals: 100% of females and 98.7% of males; one male was misclassified. Fig. 4 illustrates the distribution of discriminant

scores. The coefficients used to calculate the discriminant scores were as follows: culmen 0.058, head 0.595, tarsus 0.496, middle toe 0.157, sternum 0.364. The scores produced by these coefficients had overall zero mean and unit standard deviation within gender. Equations to classify the gender of unsexed birds using all five variables are shown in Table 2. A score is calculated for each gender, and classification is assigned to the gender with the highest score

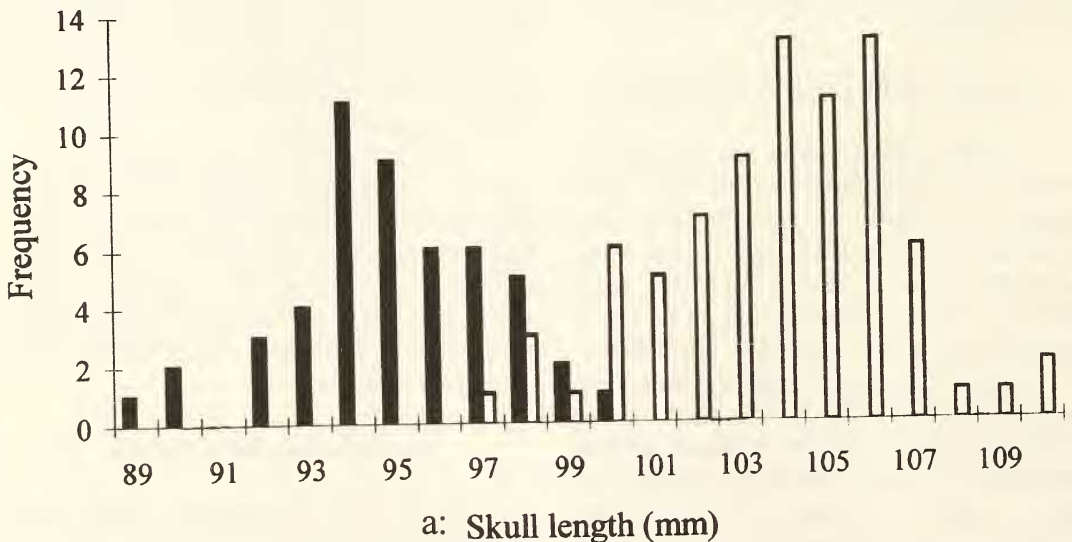


Fig. 3a: Frequency distribution of morphometric variable (skull length) for male (white bars) and female (black bars) for houbara.

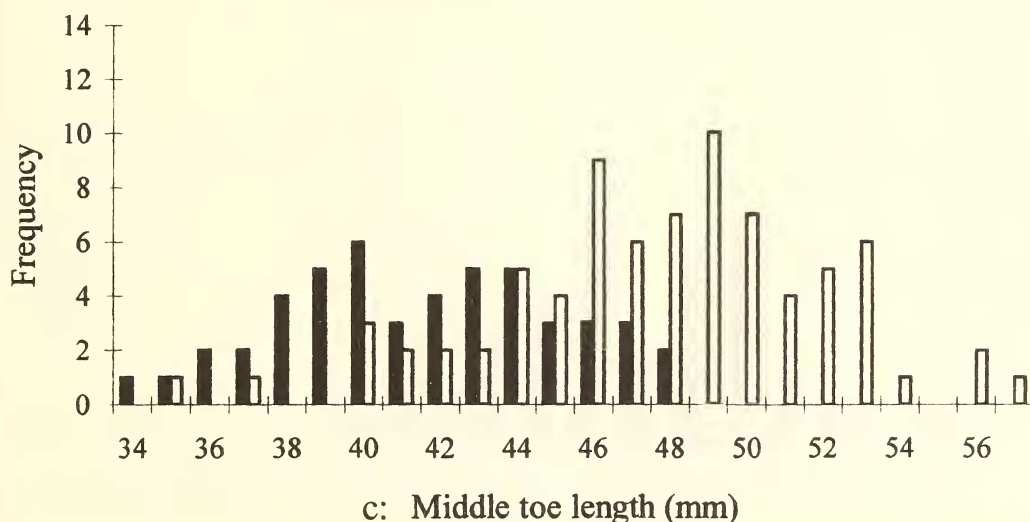
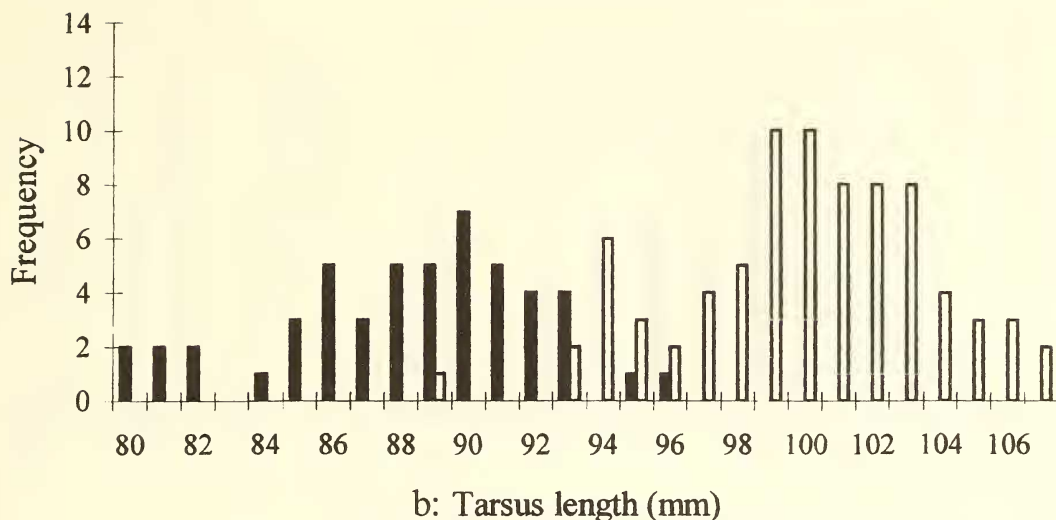


Fig. 3b and 3c: Frequency distribution of morphometric variables (tarsus length and middle toe length) for male (white bars) and female (black bars) houbara

(SYSTAT 1992). Head and tarsus length had the highest loadings on the classification equations.

Discriminant analysis using head and tarsus length only, also correctly classified 99.2% of individuals: 100% of females and 98.7% of males; one male was misclassified (the same male as above). Fig. 4 illustrates the distribution of discriminant scores. The coefficients used to calculate the discriminant scores were as follows:

head 0.700, tarsus 0.643. Equations to predict the sex of unsexed birds using head and tarsus length only, are shown in Table 2.

DISCUSSION

The ability to determine the age and sex of individual birds in a population can provide important information on aspects of

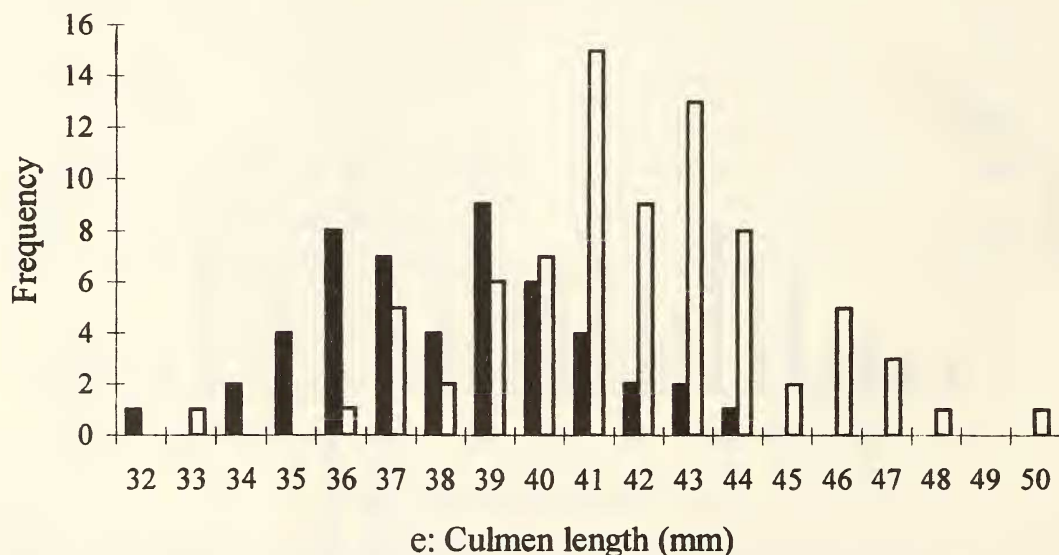
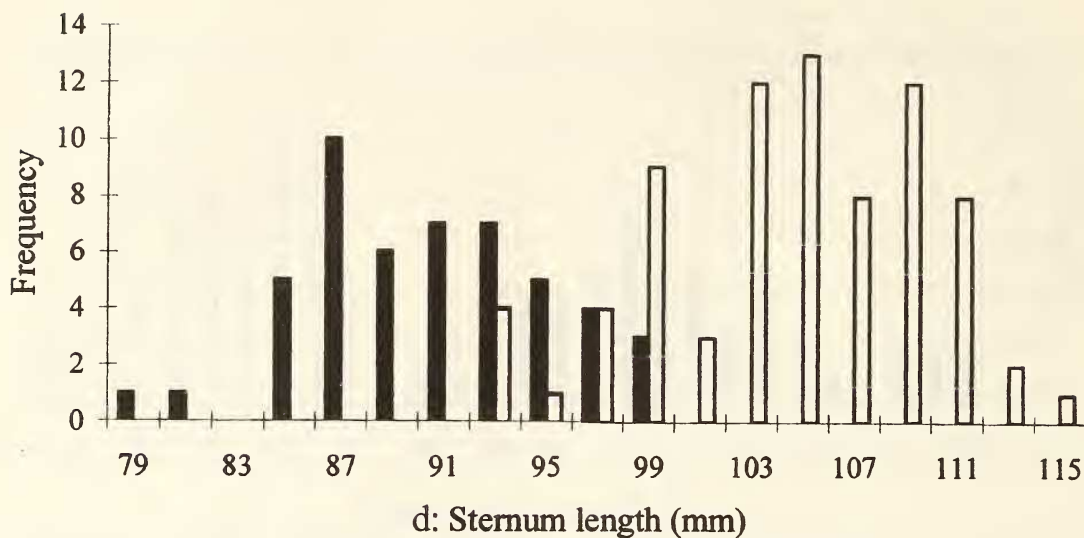
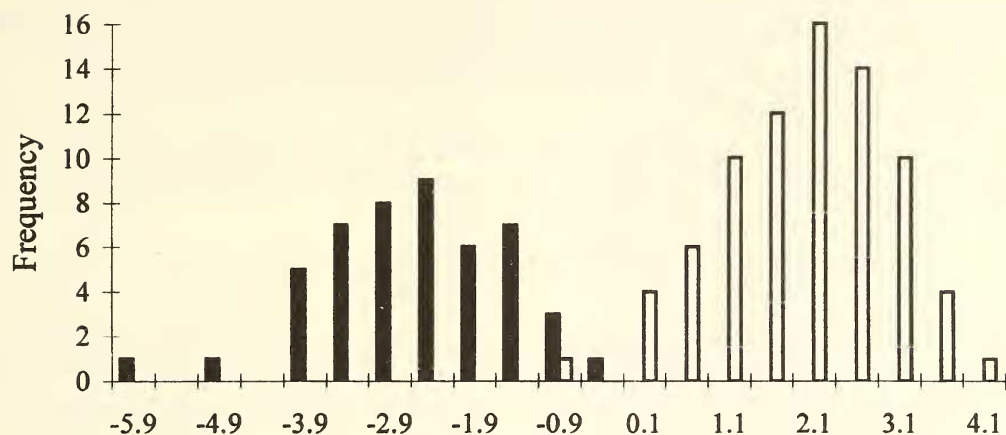


Fig. 3d and 3e: Frequency distribution of morphometric variables (sternum length and culmen length) for male (white bars) and female (black bars) houbara

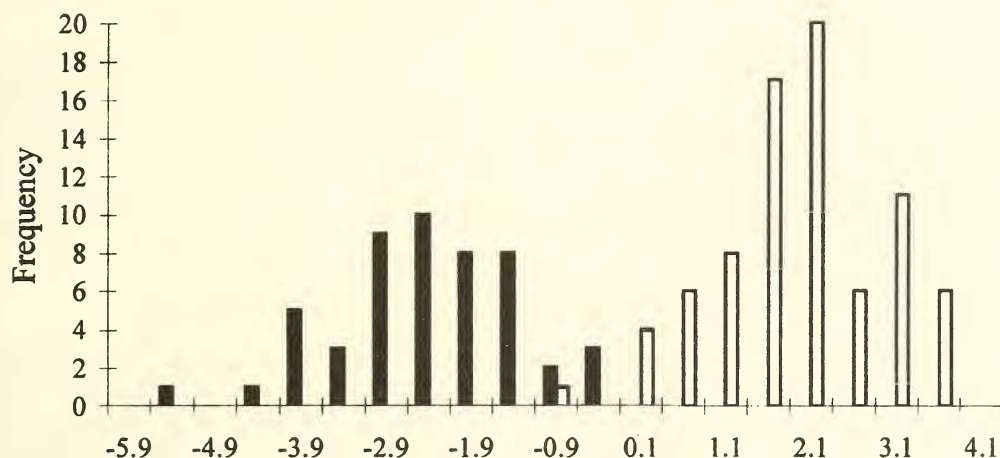
reproduction, migration and population biology (Batt *et al.* 1992). Data on recruitment, survival and mortality are especially relevant for game species, where the ability to model the dynamics of a population accurately is vital, if harvest at a sustainable level is to be achieved (Hudson and Rands 1988). It follows that a technique for ageing and sexing of houbara could be useful to

biologists examining live birds during marking operations or dead birds from hunters' bags.

We have shown that houbara in their first year retain juvenile feathers (various inner secondaries, greater secondary coverts, outer primaries and corresponding coverts, and outer tail feathers). The characteristics of these feathers can be used to separate first year from adult birds



a: Canonical score (5 variables)



b: Canonical score (2 variables)

Fig. 4a and 4b: Frequency distribution of canonical scores derived from discriminant analysis on morphometric variables with respect to the gender of adult houbara (black bars - females; white bars - males). Discriminant scores derived using five variables (culmen, head, tarsus, middle toe and sternum length) (top), and two variables (head and tarsus) only (bottom)

relatively easily. Our experience with captive birds suggests that these feathers are retained for upto 10-11 months. Furthermore, it appears that some juvenile feathering is retained by free-living birds throughout the first year of life, as

illustrated by the houbara caught in May in Kazakhstan.

It is possible that juvenile outer primaries and corresponding coverts are retained by some birds upto the age of 24 months. Cramp and

TABLE 2

CLASSIFICATION EQUATIONS TO PREDICT THE GENDER OF ADULT HOUBARA USING MORPHOMETRIC DATA: A SCORE IS CALCULATED FOR EACH GENDER, AND CLASSIFICATION IS ASSIGNED TO THE GENDER WITH THE HIGHEST SCORE (SYSTAT 1992). EQUATIONS GIVEN FOR PREDICTING GENDER USING FIVE VARIABLES (TOP), AND TWO VARIABLES ONLY (BOTTOM). MEASUREMENTS ARE IN MM.

No. of Variables	Gender	Equation
Five	Male	$-1070.227 + 13.937(\text{head}) - 1.227(\text{culmen}) + 5.183(\text{tarsus}) + 1.698(\text{sternum}) + 1.064(\text{middle toe})$
	Female	$-875.777 + 12.902(\text{head}) - 1.132(\text{culmen}) + 4.583(\text{tarsus}) + 1.382(\text{sternum}) + 0.883(\text{middle toe})$
Two	Male	$-1045.982 + 14.371(\text{head}) + 6.017(\text{tarsus})$
	Female	$-861.081 + 13.209(\text{head}) + 5.277(\text{tarsus})$

Simmons (1980) report that some retarded (late fledged) birds may not replace the outer primaries before their second winter. Therefore, care should be taken when ageing birds which have full adult-like plumage in autumn and early winter, but which show juvenile outer primaries (primaries 9-10) and corresponding coverts (primary coverts 9-10). It is probable that these individuals are second year birds, but clearly, further study of moult suspension and arrest in houbara is required.

By using discriminant analysis, the gender of adult birds was ascertained with a very high degree of accuracy. This method is superior to using a single morphometric variable, since the range of these overlap between the sexes (this study, and Cramp and Simmons 1980). We found that gender could be determined with the same degree of precision whether five or two variables were incorporated into the analysis. When attempting to ascertain the gender of adult houbara, it seems sensible to use the minimum number of measurements necessary, since this will minimise error arising from variation in measuring techniques (Barrett *et al.* 1989). It is therefore recommended that, to determine the gender of houbara, field workers use the equations incorporating head and tarsus length only.

There is evidence of a variation in body size across the range of *C. u. macqueenii*, for example, birds from Arabia have shorter wings, and wider and longer skulls, than birds from the Indian subcontinent (Osborne 1989). Therefore,

care should be taken when attempting to ascertain the gender of houbara from outside the Pakistan sub-population, using the morphometric equations provided here (which are based on birds originating from Pakistan only). Clearly there is a need to collect morphometrics from throughout the range of this species, as this will enable more accurate sex determination within the different sub-populations.

It is likely that discriminant analysis of morphometric data can also be used to determine the gender of first year birds (although it will be important to take age into account when doing so). We have collected morphometrics from birds in their first winter, but at present the gender of these individuals is not known.

ACKNOWLEDGEMENTS

We would like to thank the Crown Prince of Abu Dhabi, H.H. Sheikh Khalifa bin Zayed Al Nahyan, President of the National Avian Research Center, and H.H. Sheikh Mohammed bin Zayed Al Nahyan, Chairman of the Board, and Mr. Mohammed Al Bowardi, the Center's Managing Director, for their support and interest in the practical and research study carried out by NARC. We are also grateful to all members of the Aviculture, Veterinary and Ecology Departments for their co-operation in this study. Patrick Osborne provided assistance with statistical analyses, and John Cooper, Paul Goriup, Carl Mitchell and Ian Sleight made useful comments on an earlier draft of this manuscript.

REFERENCES

- BARRETT, R.T., M. PETERZ, R.W. FURNESS AND J. DURINCK (1989): The variability of biometric measurements. *Ring. & Migr.* 10: 13-16.
- BATT, B.D.J., A.D. AFTON, M.G. ANDERSON, C.D. ANKNEY, D.H. JOHNSON, J.A. KADLEC AND G.L. KRAPU (1992): (Eds.) Ecology and Management of Breeding Waterfowl. University of Minnesota Press, Minneapolis.
- CRAMP, S. & K.E.L. SIMMONS (1980): (Eds.) Handbook of the Birds of Europe, the Middle East and North Africa. Volume II: Hawks to Bustards. Oxford University Press, Oxford.
- GAUCHER, P., P. PAILLAT, C. CHAPPUIS, M. SAINT JALME, F. LOTFIKHAH & M. WINK (1996): Taxonomy of the Houbara Bustard *Chlamydotis undulata* subspecies considered on the basis of sexual display and genetic divergence. *Ibis* 138 (2): 273-282.
- HUDSON, P.J. & M.R.W. RANDS (1988): (Eds.) Ecology and Management of Gamebirds. BSP Professional Books, Oxford.
- JOHNSGARD, P. (1991): Bustards, Hemipodes and Sandgrouse, Birds of Dry Places. Oxford University Press, Oxford.
- LAUNAY, F. & P. PAILLAT (1990): A behavioural repertoire of the adult Houbara Bustard (*Chlamydotis undulata macqueenii*). *Rev. Ecol. (Terre Vie)* 45: 65-88.
- MENDELSSOHN, H., U. MARDERM & M. STAVY (1979): Captive breeding of Houbara (*Chlamydotis undulata macqueenii*) and a description of its display. *ICBP Bull.* 13: 134-139.
- OSBORNE, P. (1989): The bustard morphometrics data base: an introduction and some preliminary findings. *Bustard Studies* 4: 125-134.
- SYSTAT (1992): SYSTAT for Windows: Statistics, Version 5 Edition. SYSTAT Inc., Evanston, Illinois.

